

The Interaction of Lexical and Grammatical Tone in the Bulu Verb System

Honors Research Thesis

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by

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Abstract

This thesis, based on original fieldwork, describes processes of tonal interaction between verbs and direct objects in Bulu, a Bantu language of Cameroon. It is principally concerned with two processes which can affect the tones of object nouns when they occur immediately after the verb. The first is a process of tonal agreement, in which the initial tone of the object changes to match the level of the final tone of the verb stem. The second is a process by which the object noun is assigned a high tone on the initial syllable.

The current work serves to offer a more complete description of these processes in Bulu than that which was noted by previous researchers, such as Yukawa (1992). It notes that patterns of tonal agreement can be triggered by both high and low-toned verb stems. Additionally, subsequent tones in the object noun can be affected if either tonal agreement or initial high tone assignment deletes an initial low that is the only low tone in the word.

This thesis also offers a description of environments which can trigger or block these tonal interactions. Each of these patterns is conditioned by particular TAM morphemes, and an account of this based on morphological conditioning and floating high tones is proposed. Prosodic conditioning of these patterns is also proposed based on phrase structure, with both agreement and high tone assignment patterns blocked by intervening phonological phrase boundaries.

Furthermore, an analysis of these two tonal processes is offered using both autosegmental representations (Goldsmith 1976) to demonstrate the proposed tonal structure of these words as well as constraints within an Optimality Theory framework (Prince and Smolensky 1993) to provide an account of the phonological grammar responsible for these patterns. It is demonstrated that a single unified analysis can account for these two distinct patterns, and this analysis is used to argue for an elevated status of low tones within the grammar of Bulu. This importance of low tones suggests that Bulu can be classified as displaying an underlying contrast between high and low tones, rather than the contrast between high and toneless that has been posited for many other Bantu languages.

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I wish I could list all of the other individuals who have helped me along the way, either professionally or personally, though I know that would be an impossible endeavor.

Despite all of the direction and assistance from these incredible people, it is possible that there remain errors in the current work. These errors are mine and mine alone.

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1 Introduction

This work utilizes original fieldwork data to describe two processes of tonal interaction between verbs and direct object nouns in Bulu. Evidence is presented for a process of tonal agreement between verb stems and nouns as well as a process of initial high tone assignment due to floating tones. Crucially, these patterns differ from tonal interactions previously noted for the language. An analysis of these processes is presented using autosegmental representations and an Optimality Theory framework of ranked constraints. In addition to providing data on these tonal processes, this work presents evidence for the prominent role of low tones in the grammar of Bulu compared to many other Bantu languages, suggesting that this language may be of potential interest from a typological perspective. The remainder of Section 1 provides background information on Bulu and on the phonological theories utilized in this work. Section 2 summarizes previous accounts of similar phenomena and provides data from Bulu to illustrate both tonal processes. It also discusses both morphological and prosodic factors that condition these patterns. Section 3 provides an analysis of both processes. Finally, Section 4 provides a summary and suggests potential areas for future research based on the findings of this paper.

1.1 Background on Bulu

1.1.1 Language Background

Bulu is a Bantu language (A.74) of southern Cameroon. It is used as a “language of wider communication,” and is spoken by approximately 858,000 speakers (Lewis et al. 2013). Bulu has been studied at several points in its history by scholars including Bates (1926), Yukawa (1992), and Abomo-Maurin (2006). The data in this thesis are taken entirely from original fieldwork conducted with a speaker from the Sangmélima area currently living in Columbus, Ohio. This speaker is also fluent in French and English.

1.1.2 Tone

Bulu uses both lexical and grammatical tone to contrast meaning. The language makes use of two phonological tone levels, high (H) and low (L). Surface tones can also include rising and falling tones. However, these surface contours can be analyzed as consisting of a combination of two underlying level tones (LH or HL, respectively). Additionally, certain phonological and morphological processes can trigger downstep ([↓]) of high tones, lowering the phonetic realization of the tone to a pitch between that of high and low.

1.1.3 Morphology

In order to analyze the interaction of verbs and object nouns in Bulu, it is necessary to understand the basics of noun and verb morphology.

Like many Bantu languages, Bulu makes use of a robust noun class system. Singular and plural classes are typically paired to form a grammatical gender. Nouns consist of a stem which encodes the basic meaning of the word as well as the grammatical gender (Bates 1926). Nouns are also marked by a class prefix (for some classes this takes the form of a null prefix), which agrees with the stem gender (Maho 1999) and encodes number (Carstens 1993). Basic noun morphology is shown in (1) and (2). In these examples, because the stems ‘person’ and

‘okra’ are of different grammatical genders, they each use a different set of class morphemes to express singular and plural¹:

- | | |
|---|--|
| <p>(1) a. m-òt
CL₁-person
‘person’</p> <p>b. b-òt
CL₂-person
‘people’</p> | <p>(2) a. è-tétám
CL₇-okra
‘okra (sg.)’</p> <p>b. bì-tétám
CL₈-okra
‘okra (pl.)’</p> |
|---|--|

In their simplest form, Bulu verbs are composed of a stem, a subject prefix, and one or more tense, aspect, and modality (TAM) markers. Verb stems have lexically specified tones, and this thesis will be primarily concerned with the lexically specified tone of the final syllable of the verb stem. Subject prefixes in Bulu typically have a pronominal function or display agreement with the subject’s noun class and are low-toned. Finally, TAM markers can consist of a combination of phonological segments, tones overtly realized on those segments, and floating grammatical tones which can trigger tonal processes on other morphemes as a result of certain syntactic constructions. A simple illustration of a Bulu verb is given in (3):

- (3) mà-ŋgá-dzǐ
1.SG-PST-eat
‘I ate’

Table 1 shows the properties of the TAM markers discussed in this paper². For all of these tenses, the low-toned subject marker is prefixed before all other elements. Further discussion of the properties of these TAM markers can be found in Section 2.3.

Table 1: Selected Verb Tenses of Bulu³

Tense	Marker
Present	stem
Past	ŋgá + stem
Recent Past 1	kó + <u>L</u> + stem + <u>H</u>
Recent Past 2	´ + stem
Future	êj + stem + <u>H</u>

1.2 Theoretical Framework

The current work will make use of two theoretical approaches to phonology, the former, representational, and the latter, computational. The rationale behind selecting each of these frameworks as well as a brief overview of each theory will be given below.

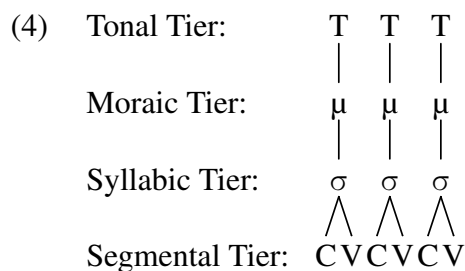
¹CL_# = noun class number

²Labels for these tenses represent descriptions given by the consultant rather than a detailed classification of the functions of these tenses.

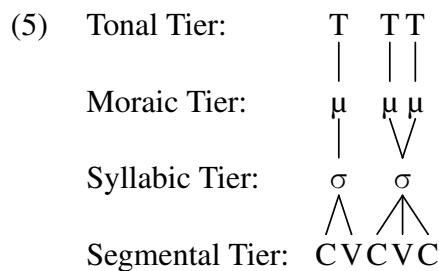
³Underlines indicate floating tones.

1.2.1 Autosegmental Phonology

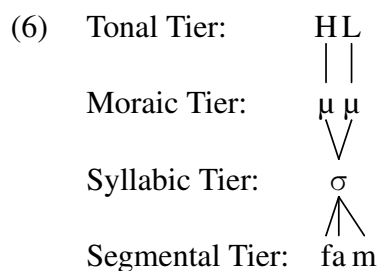
Goldsmith (1976) introduces the concept of autosegmental phonology as a way to represent suprasegmental elements, that is, elements that scope over a unit larger than a single segment, such as a syllable. Within this framework, words are viewed as consisting of multiple tiers, which are associated with one another in a systematic manner. In this way, elements from one tier can be associated with elements of another tier. By positing multiple tiers, the theory can account for seemingly non-local effects by positing adjacency at higher tier levels. Therefore, phonological processes can still be viewed as an interaction of adjacent elements. This is particularly useful in the study of tone since tonal interactions typically operate on units larger than the individual segment. This paper will mostly be concerned with the tonal, moraic, and syllabic tiers. A representation of this word structure is given in (4):



In this figure, elements of one tier are associated to elements of other tiers via the solid association lines. In Bulu, the mora, a unit of syllable weight, is the tone bearing unit (TBU). Therefore, tones from the tonal tier are associated to morae in the moraic tier in a one-to-one correspondence. These morae are then associated to syllables in the syllabic tier which are then associated to the phonological segments in the segmental tier. Multiple consonants and vowels can be associated to the same syllable, and, likewise, multiple morae can be associated to the same syllable. An example of a multi-moraic syllable is given in (5):



Multiple morae are associated to heavy syllables, typically syllables containing coda consonants or long vowels. When the tones associated with these morae are not of the same level, this results in the surface contour tones noted in Section 1.1.2. An example of this is given in (6). This structure results in the Bulu word in (7).



- (7) fām
‘man’

The Bulu word for ‘man’ has a falling tone. In line with analyses of other level tone languages, this contour tone is posited to be a result of both a H and L from the tonal tier being realized on the same syllable (Goldsmith 1976, *inter alia*). This is represented by the structure in (6) where the bimoraic syllable is associated to a H and L.

Through phonological processes, elements from one tier can become associated to different elements of other tiers. These new associations are indicated with dashed lines as seen in the simplified representation in (8):

- (8) Tonal Tier: T T
 | \ |
Syllabic Tier: σ σ

Likewise, elements from one tier can become dissociated from elements in another tier, which is indicated by two small horizontal lines perpendicular to the original association line, as seen in (9):

- (9) Tonal Tier: T T
 | \ |
Syllabic Tier: σ σ

In this example, the second syllable would now be realized with the first tone, rather than the second tone, which was originally associated with it.

As mentioned previously, this paper will utilize autosegmental phonology as a mainly representational device to show underlying tones and their realization on phonological segments of Bulu words. Therefore, for the remainder of this work, autosegmental representations will be given with phonetic transcription of the Bulu word on the lower tier and the tones on the higher tier. This format is demonstrated in (10), which is a simplified version of (6).

- (10) H L
 \ /
 fām

1.2.2 Optimality Theory

Optimality Theory (OT) is a theoretical framework for phonology proposed by Prince and Smolensky (1993). This theory assumes a phonological grammar consisting of a series of well-formedness constraints. For any given input to this grammar, the grammar computes the output that best satisfies this set of constraints, that is, the optimal output.

The well-formedness constraints of the phonological grammar are largely in conflict with one another. Because of this, most potential outputs will violate some set of these constraints. These conflicting constraints are, however, ranked with respect to one another, meaning that the satisfaction of one constraint takes precedence over the satisfaction of another. With this *strict dominance hierarchy* in place, the grammar can then compute the optimal candidate (Prince and Smolensky 1993).

For each input to the grammar, there exists a series of potential output candidates. Each candidate incurs violations of the ranked well-formedness constraints, with violations of highly ranked constraints being worse than violations of lower constraints. The candidate that best satisfies this set of constraints compared to all other possible output candidates is selected by the grammar as the optimal candidate. This candidate corresponds to the actual surface form. Because the ranking of constraints is language specific, the optimal outputs, and therefore the surface forms, will differ from language to language.

Constraints within OT fall into two general categories: faithfulness and markedness. Faithfulness constraints refer to the realization of each feature or segment of the input form in the output form. A violation of a faithfulness constraint occurs when an element of the input form is not present in the output candidate or when an element of the output candidate was not present in the input form. Markedness constraints, however, refer to an overall preference or dispreference for a certain surface segment or feature. A violation of a markedness constraint occurs when an output candidate contains the dispreferred element. It is through the interaction of faithfulness and markedness constraints that the grammar yields the optimal output for any possible input.

To represent this grammar of ranked constraints within OT, tableaux are used to illustrate the constraints and the various possible output candidates. The input form is listed within slashes (/ /) in the upper left corner and the constraints are listed along the top row, with the highest ranked constraints on the left. Solid lines between columns indicate a definite ranking of constraints with respect to one another, and dashed lines indicate that two constraints are not ranked with respect to one another or that their ranking cannot be determined from the data at hand. Possible output candidates are listed in the leftmost column, and violations incurred by each candidate are indicated by asterisks (*) in the appropriate column. An exclamation point (!) denotes the fatal violation that causes a candidate to lose, and a pointing hand (☞) indicates the winning (optimal) candidate. Finally, shaded cells denote the constraints that are irrelevant for evaluating each individual candidate due to the incurrance of a fatal violation of a higher ranked constraint. An example tableau is given in (11):

(11)

Input: /xyxy/	FAITH ₁	*MARKEDNESS ₁	FAITH ₂	*MARKEDNESS ₂
a. ☞ xyxy				*
b. xyxx		*!	*	*
c. xyx	*!			*

In this tableau, Candidate a is selected by the grammar as the optimal candidate because it only violates the lowest ranked markedness constraint. Candidates b and c both incur higher-ranking, and therefore fatal, constraint violations.

2 Tonal Interactions

This work is mainly concerned with two types of tonal interactions that can occur between verbs and immediately adjacent direct object nouns in Bulu. Section 2.1 discusses previous accounts of these and similar phenomena in Bulu and other African languages. Section 2.2 provides relevant data from Bulu for these two separate processes. Section 2.3 provides an argument for

the morphological conditioning of the two processes based on properties of specific verb TAM markers, and Section 2.4 provides evidence for prosodic conditioning of these tonal processes based on prosodic domain boundaries. An analysis of these data using the frameworks of autosegmental phonology and Optimality Theory will be taken up in Section 3.

2.1 Previous Accounts

Interactions between verbs and direct object nouns as well as verbs and object pronouns are briefly described by Yukawa (1992) in his study of the tonology of Bulu verbs. He notes that exclusively after verbs with final high tones, direct objects can undergo various tonal changes affecting the tone of the initial syllable. A summary of the tonal changes he describes is given in (12).

- (12) (C)Ṽ(C)(CṼ~) → (C)Ṽ(C)(CṼ~)
 (C)ṼCṼ~ → (C)ṼCṼ~
 (C)ṼCṼ~ → (C)ṼCṼ~
 (C)ṼCCṼ~ → (C)ṼCṼ~
 (C)ṼCCṼ~ → (C)ṼCCṼ~

All of the changes in (12) involve the initial low tone of an object becoming either high or falling, depending on the structure of the word. Since it was already shown in Section 1.2.1 that contour tones involve distinct high and low tones on the tonal tier, all of these processes can be described as being an addition of a high tone to the first syllable of the direct object noun. Though Yukawa (1992) does not offer an explanation of this phenomenon, it can potentially be classified as a type of tone raising, since low-toned objects are gaining a high-tone component after high-toned verbs.

A similar process of raising has been described for the Chadic language Bole (Gimba 1998). In Bole, low-tone initial objects raise to become initially high-toned after high-toned verbs. This is consistent with other processes of low tone raising (LTR) in the language. Gimba (1998) crucially notes that this raising is conditioned only within certain prosodic domains, however. This prosodic conditioning will be shown to be important in Bulu as well.

Finally, Goldsmith (1976) notes various processes of tonal interaction between verbs and both object suffixes and nouns in the Niger-Congo language Igbo. For toneless (Class I) object suffixes, he notes that they can either take on the tone of the verb stem or that they can take on the floating high tone suffix that follows certain verbs. Furthermore, in a process which he calls Object Tone Mutation, object nouns which do bear specified lexical tones can also undergo tonal changes after these floating high tone suffixes. An overview of his classification of these changes is given in (13).

- (13) H → M
 HH → HM
 LH → MH
 HL → HL
 LL → LL

It will be seen that floating high tones can similarly affect the tones of direct object nouns in Bulu. Additionally, while Goldsmith (1976) only notes objects taking on the tones of verb

stems in the case of toneless object suffixes, it will be argued that even object nouns that are lexically specified for tone can surface with the verb stem tone in Bulu.

2.2 Bulu Data

When a direct object noun occurs immediately after a verb, one of two distinct tonal processes can be triggered. The initial tone of the noun can either change to agree with the final tone of the verb stem, or the noun can gain an initial high tone. Data illustrating these two processes will be given below.

2.2.1 Tonal Agreement

After verbs of certain tenses, the initial tone of the direct object noun changes to the same tone level as the final tone of the verb stem. One tense for which this happens is the present tense. In the examples below, nouns are given in citation form as well as after the high-toned stem ‘eat’ and the low-toned stem ‘buy’ to show the effects of this tonal agreement process on the tone of the noun.⁴

(14)	a.	bíkòn ‘plantains’	màdží bíkòn ‘I am eating plantains’	màkùs bíkòn ‘I am buying plantains’
	b.	mímbàŋ ‘palm nuts’	màdží mímbàŋ ‘I am eating palm nuts’	màkùs mímbàŋ ‘I am buying palm nuts’
	c.	ódzòì ‘banana’	màdží ódzòì ‘I am eating a banana’	màkùs ódzòì ‘I am buying a banana’
	d.	ónòn ‘bird’	màdží ánòn ‘I am eating birds’	màkùs ònòn ‘I am buying a bird’
	e.	ówùndò ‘peanut’	màdží ówùndò ‘I am eating peanuts’	màkùs ówùndò ‘I am buying peanuts’
	f.	bìlók ‘grass’	jàdží bìlók ‘(The cow) is eating grass’	màkùs bìlók ‘I am buying grass’
	g.	òdzói ‘duiker’ ⁵	màdží ódzói ‘I am eating a duiker’	màkùs ódzói ‘I am buying a duiker’
	h.	òsán ‘squirrel’	màdží ósán ‘I am eating a squirrel’	màkùs òsán ‘I am buying a squirrel’
	i.	bìtétám ‘okra (pl.)’	màdží bítétám ‘I am eating okra’	màkùs bìtétám ‘I am buying okra’
	j.	èsíngì ‘cat’	màdží bísíngì ‘I am eating cats’	màkùs èsíngì ‘I am buying a cat’
	k.	òfùmbí ‘orange’	màdží ófùmbí ‘I am eating an orange’	màkùs òfùmbí ‘I am buying an orange’

⁴Boldface indicates initial syllables that have changed from the tone of their citation form.

⁵A small antelope

The nouns in (14a-14e) have an initial high tone in isolation. They remain high-toned after the high-toned verb stem ‘eat’. However, after the low-toned stem ‘buy’, the initial high tone becomes low. A similar pattern is seen with the nouns in (14f-14k), which have an initial low tone in isolation. They remain low-toned after the low-toned stem ‘buy’, but gain an initial high tone after the high-toned stem ‘eat’. The same patterns are seen with what will be referred to as the ‘past’ and ‘recent past 2’⁶ in (15) and (16) below.

- | | | | | |
|------|----|-------------------------|--|--|
| (15) | a. | bíkòn
‘plantains’ | màṅgádží bíkòn
‘I ate plantains’ | màṅgákùs bíkòn
‘I bought plantains’ |
| | b. | mím̀bàṅ
‘palm nuts’ | màṅgádží mím̀bàṅ
‘I ate palm nuts’ | màṅgákùs mím̀bàṅ
‘I bought palm nuts’ |
| | c. | ódzòì
‘banana’ | màṅgádží ódzòì
‘I ate a banana’ | màṅgákùs ódzòì
‘I bought a banana’ |
| | d. | ónòn
‘bird’ | màṅgádží ónòn
‘I ate a bird’ | màṅgákùs ónòn
‘I bought a bird’ |
| | e. | óẁòndò
‘peanut’ | màṅgádží óẁòndò
‘I ate peanuts’ | màṅgákùs óẁòndò
‘I bought peanuts’ |
| | f. | bìlók
‘grass’ | èṅgádží bìlók
‘(The cow) ate grass’ | màṅgákùs bìlók
‘I bought grass’ |
| | g. | òdzói
‘duiker’ | màṅgádží ódzói
‘I ate a duiker’ | màṅgákùs òdzói
‘I bought a duiker’ |
| | h. | òsán
‘squirrel’ | màṅgádží ósán
‘I ate a squirrel’ | màṅgákùs òsán
‘I bought a squirrel’ |
| | i. | bìtétám
‘okra (pl.)’ | màṅgádží bìtétám
‘I ate okra’ | màṅgákùs bìtétám
‘I bought okra’ |
| | j. | èsíṅgì
‘cat’ | màṅgádží ésíṅgì
‘I ate a cat’ | màṅgákùs èsíṅgì
‘I bought a cat’ |
| | k. | òfùmbí
‘orange’ | màṅgádží ófùmbí
‘I ate an orange’ | màṅgákùs òfùmbí
‘I bought an orange’ |
| (16) | a. | bíkòn
‘plantains’ | mădží bíkòn
‘I ate plantains’ | măkùs bíkòn
‘I bought plantains’ |
| | b. | mím̀bàṅ
‘palm nuts’ | mădží mím̀bàṅ
‘I ate palm nuts’ | măkùs mím̀bàṅ
‘I bought palm nuts’ |
| | c. | ódzòì
‘banana’ | mădží ódzòì
‘I ate a banana’ | măkùs ódzòì
‘I bought a banana’ |
| | d. | ónòn
‘bird’ | mădží ónòn
‘I ate a bird’ | măkùs ónòn
‘I bought a bird’ |

⁶Though this tense is judged by the consultant as semantically equivalent to the tense referred to as ‘recent past 1’ in the following section, it is typically an acceptable but less-preferred option for expressing events occurring on the same day as the time of utterance. As mentioned previously, this work makes no attempt to offer a complete semantic description of the function of these tenses.

e.	ówùndò 'peanut'	mădzí ówùndò 'I ate peanuts'	măkùs òwùndò 'I bought peanuts'
f.	bìlók 'grass'	jědzí bílòk '(The cow) ate grass'	măkùs bìlók 'I bought grass'
g.	òdzói 'duiker'	mădzí ódzòì 'I ate a duiker'	măkùs òdzói 'I bought a duiker'
h.	òsán 'squirrel'	mădzí ósàn 'I ate a squirrel'	măkùs òsán 'I bought a squirrel'
i.	bìtétám 'okra (pl.)'	mădzí bítètám 'I ate okra'	măkùs bìtétám 'I bought okra'
j.	èsíngì 'cat'	mădzí ésíngì 'I ate a cat'	măkùs ésíngì 'I bought a cat'
k.	òfùmbí 'orange'	mădzí ófùmbí 'I ate an orange'	măkùs òfùmbí 'I bought an orange'

An important pattern to note is that when high-tone initial nouns become low-tone initial after a low-toned stem as in (14a-14e), (15a-15e), and (16a-16e), the subsequent tones in the words remain unchanged. However, when low-tone initial nouns become high-tone initial after high-toned stems, this can trigger changes in other tones in the word. Two-syllable words that are L-H in isolation become H-L after high-toned stems as seen in (14f-14h), (15f-15h), and (16f-16h). The low-tone initial word [bìtétám] 'okra (pl.)' changes from L-H-H to H-L-L after high-toned stems in (14i), (15i), and (16i). However, the low-tone initial nouns [èsíngì] and [òfùmbí] do not undergo any additional changes in the subsequent tones in the words as seen in (14j-14k), (15j-15k), and (16j-16k). After high-toned verb stems, therefore, the following changes can occur to low-tone initial nouns:

- (17)
- a. L-H → H-L
 - b. L-H-H → H-L-L
 - c. L-H-L → H-H-L
 - d. L-L-H → H-L-H

By examining the patterns in (17), it appears that the subsequent tones in a word change only when the addition of an initial high tone would result in the deletion of the only low tone in the word. In the patterns in (17a) and (17b), the initial low tones are the only lows in the words, and the subsequent tones change to L after the agreement process causes the first tone to be an H. However, in the patterns in (17c) and (17d), there is another L in the word in addition to the initial tone. In these cases, only the initial tone changes. As noted previously, the deletion of initial high tones after low-toned stems does not trigger changes in the other tones of the word, even if the deleted H is the only H in the word. Taken together, these patterns would suggest that the grammar of Bulu places some higher preference on preserving at least some trace of a lexical L in a word. This tendency will be discussed further in Section 3.

2.2.2 Initial High Tone Assignment

Another pattern that can affect the tones of direct object nouns immediately following verbs will be referred to as initial high tone assignment. When nouns occur after verbs of a particular

subset of tenses, they become invariably high-toned on the initial syllable. This process occurs regardless of the final tone of the verb stem, in contrast to the pattern seen in Section 2.2.1. One tense that illustrates this pattern will be referred to as ‘recent past 1’. In (18), nouns are given in their citation form as well as after the high-toned stem ‘eat’ and the low-toned stem ‘buy’, as before.

(18)	a.	bíkòn ‘plantains’	màkó ⁺ dží bíkòn ‘I ate plantains’	màkókùs bíkòn ‘I bought plantains’
	b.	mím̀bàṅ ‘palm nuts’	màkó ⁺ dží mím̀bàṅ ‘I ate palm nuts’	màkókùs mím̀bàṅ ‘I bought palm nuts’
	c.	ódzòì ‘banana’	màkó ⁺ dží ódzòì ‘I ate a banana’	màkókùs ódzòì ‘I bought a banana’
	d.	ónòn ‘bird’	màkó ⁺ dží ónòn ‘I ate a bird’	màkókùs ónòn ‘I bought a bird’
	e.	ówùndò ‘peanut’	màkó ⁺ dží ówùndò ‘I ate peanuts’	màkókùs ówùndò ‘I bought peanuts’
	f.	bìlók ‘grass’	jàkó ⁺ dží bílók ‘(The cow) ate grass’	màkókùs bílók ‘I bought grass’
	g.	òdzói ‘duiker’	màkó ⁺ dží ódzói ‘I ate a duiker’	màkókùs ódzói ‘I bought a duiker’
	h.	òsàn ‘squirrel’	màkó ⁺ dží ósàn ‘I ate a squirrel’	màkókùs ósàn ‘I bought a squirrel’
	i.	bìtétám ‘okra (pl.)’	màkó ⁺ dží bítétám ‘I ate okra’	màkókùs bítétám ‘I bought okra’
	j.	èsíṅgì ‘cat’	màkó ⁺ dží ésíṅgì ‘I ate a cat’	màkókùs ésíṅgì ‘I bought a cat’
	k.	òfùmbí ‘orange’	màkó ⁺ dží ófùmbí ‘I ate an orange’	màkókùs ófùmbí ‘I bought an orange’

In (18a-18e), the high-tone initial nouns undergo no change after either the high-toned stem ‘eat’ or the low-toned stem ‘buy’. In contrast, the low-tone initial nouns in (18f-18k) gain an initial high tone after both verbs. This pattern is confirmed for the future tense, as well, in (19).

(19)	a.	bíkòn ‘plantains’	mêjdží bíkòn ‘I will eat plantains’	mêjkùs bíkòn ‘I will buy plantains’
	b.	mím̀bàṅ ‘palm nuts’	mêjdží mím̀bàṅ ‘I will eat palm nuts’	mêjkùs mím̀bàṅ ‘I will buy palm nuts’
	c.	ódzòì ‘banana’	mêjdží ódzòì ‘I will eat a banana’	mêjkùs ódzòì ‘I will buy a banana’
	d.	ónòn ‘bird’	mêjdží ónòn ‘I will eat a bird’	mêjkùs ónòn ‘I will buy a bird’
	e.	ówùndò ‘peanut’	mêjdží ówùndò ‘I will eat peanuts’	mêjkùs ówùndò ‘I will buy peanuts’

f.	bílók 'grass'	jêjdzí bílók '(The cow) will eat grass'	mêjkùs bílók 'I will buy grass'
g.	òdžói 'duiker'	mêjdží ódžói 'I will eat a duiker'	mêjkùs ódžói 'I will buy a duiker'
h.	òsàn 'squirrel'	mêjdží ósàn 'I will eat a squirrel'	mêjkùs ósàn 'I will buy a squirrel'
i.	bítétám 'okra (pl.)'	mêjdží bítétám 'I will eat okra'	mêjkùs bítétám 'I will buy okra'
j.	èsíngì 'cat'	mêjdží ésíngì 'I will eat a cat'	mêjkùs ésíngì 'I will buy a cat'
k.	òfùmbí 'orange'	mêjdží ófùmbí 'I will eat an orange'	mêjkùs ófùmbí 'I will buy an orange'

For the nouns undergoing initial high tone assignment in (18) and (19), subsequent tones of the word can also undergo changes. These changes are identical to the changes occurring with nouns undergoing the process of tonal agreement seen in Section 2.2.1. If the assignment of an initial high tone would result in the loss of the only L in the word, subsequent high tones can change to low to preserve this lexical L.

2.3 Morphological Conditioning

The data in Sections 2.2.1 and 2.2.2 would suggest that the two distinct tonal interactions between verbs and object nouns are morphologically conditioned. Specifically, it appears that the presence of certain TAM markers conditions each of the possible tonal processes. It is possible to assume that both tonal agreement and initial high tone assignment are triggered only by the presence of a specific set of TAM morphemes. Alternatively, one can assume that one of these two patterns is the result of a default process occurring after all verbs, and that the other is conditioned only by a subset of morphemes.

Under the assumption that one of these processes is a general rule of Bulu, one could argue that nouns in object position are assigned a default initial high tone and that tonal agreement is triggered by only a certain set of TAM morphemes. Alternatively, it could be argued that tonal agreement between verbs and nouns is the more general phonological process, and that initial high tones on objects are triggered only by a subset of morphemes. In line with previous analyses of other African languages, this work adopts the latter hypothesis.

As mentioned in Section 2.1, Goldsmith (1976) attributes Object Tone Mutation in Igbo to a floating high tone after the verb stem. He argues that these floating high tones are a suffixal component of certain TAM markers. When verbs are followed by objects, these suffixal tones without any existing associations to the syllabic tier become associated to the first syllable of the object.

A similar analysis can account for the morphologically conditioned variability of verb and object tone interaction in Bulu. If a suffixal high tone is posited for TAM morphemes like the 'recent past 1' and 'future' markers, this could account for the behavior seen in (18) and (19). After verbs of these tenses, direct objects invariably surface with initial high tones, regardless of the tone of the verb stem. If these TAM markers include a floating high tone, as posited for Igbo (Goldsmith 1976), it would surface on the initial tone of the object noun. Under

this hypothesis, one could argue that the default tonal process occurring between verbs and nouns is tonal agreement. However, the floating suffixal high tone accompanying certain TAM markers becomes associated to the initial syllable of the object noun, blocking or obscuring the agreement process by causing all nouns to surface with an initial high tone. A further discussion and analysis of the interaction of these processes is found in Section 3.

Table 1 is duplicated below to illustrate the posited structure of the tense markers discussed in this paper.

Table 1: Selected Verb Tenses of Bulu⁷

Tense	Marker
Present	stem
Past	ɲgá + stem
Recent Past 1	kó + <u>L</u> + stem + <u>H</u>
Recent Past 2	´ + stem
Future	êj + stem + <u>H</u>

It is useful to note at this point in the discussion that floating tones accompanying specific TAM markers can be helpful in explaining other tonal processes in the Bulu verb, as well. For example, a floating L is posited before the verb stem for the ‘recent past 1’ marker, in addition to the suffixal H. This low tone is used to explain the downstep that occurs after this high-toned [kó] marker for ‘recent past 1’ but not after the high-toned [ɲgá] marker of the ‘past’, as illustrated in (20).

- (20) a. mà-kó-[↓]dʒí
 1.SG-RECPST1-eat
 ‘I ate’
 b. mà-ɲgá-dʒí
 1.SG-PST-eat
 ‘I ate’

This morpheme-specific downstep process seen before the stem in (20a) cannot be explained as being triggered by two adjacent high tones, since downstep does not occur when two high tones occur adjacent to one another in (20b). A floating low tone that is part of the TAM morpheme for the ‘recent past 1’ marker can, however, explain the difference in the tonal behavior of these two TAM markers. This provides support, therefore, for the presence of floating tones specific to certain TAM morphemes elsewhere within Bulu verb morphology.

2.4 Prosodic Conditioning

In addition to morphological conditioning, these two processes of tonal interaction are also subject to prosodic conditioning. As mentioned in Section 2.1, Gimba (1998) notes that low tone raising in Bole is blocked if the verb and object noun do not occur within the same prosodic domain, specifically the same Phonological Phrase. A similar conditioning appears to affect the processes of tonal agreement and initial high tone assignment in Bulu. Specifically, if

⁷Underlines indicate floating tones.

a prosodic domain boundary occurs between the verb and noun, both of these processes are blocked. In other words, both types of tonal interaction between verbs and direct object nouns can only occur within the same prosodic domain. This point is illustrated with a particularly interesting case of a tonal morpheme in the following discussion.

Bulu exhibits a reflex of the Proto-Bantu augment morpheme, also referred to as the Bantu ‘initial vowel’ or ‘pre-prefix’ (Maho 1999). This morpheme serves various functions across different languages of the Bantu family, but it is often used to express concepts related to definiteness or specificity. There is substantial phonological variability in the realization of this morpheme across Bantu languages as well, though it typically has more than one form in a given language (de Blois 1970). It is often realized as a vowel prefix preceding the noun class prefix. In some languages, the augment has presumably undergone historical reduction, resulting in the loss of the segmental element of the augment and the preservation of only the tonal element. Furthermore, some languages exhibit both segmental and tonal allomorphs of the augment.

The Bulu augment is realized as [ɔ̌] before nouns with class prefixes that are either a consonant or null. It is realized as solely a high tone on nouns with class prefixes that are vowels or of the form CV (Alexandre 1970). An example of the two forms of the augment are given in (21).

- (21) a. ɔ̌-b-òt
 AUG-CL₂-person
 ‘(the) people’
 b. bi-tétám
 AUG.CL₈-okra
 ‘(the) okra (pl.)’

In (21a), the high-toned schwa is the segmental form of the augment. It occurs before the consonant prefix [b] of class 2. In (21b), the noun class prefix for class 8 is [bi]. The word for ‘okra (pl.)’ has an initial low tone in citation form as seen in previous examples, such as (14i), where it surfaces as [bǐtétám] in isolation. However, in (21b), the tonal form of the augment, which is realized as a high tone on the first syllable of the noun, causes the word to be initially high-toned instead.

In addition to their phonological differences, the segmental and tonal forms of the Bulu augment differ in their syntactic distribution and semantic function (Barlew and Clem 2014). Only the tonal allomorph of the augment will be considered for the purposes of the current discussion.

The tonal augment occurs as a high tone on the initial syllable of nouns with various types of post-nominal modifiers, including demonstratives and relative clauses. Its occurrence is syntactically licensed by the presence of these post-nominal elements. When nouns with post-nominal modifiers occur as direct objects after verbs, the presence of the augment can affect the realization of tonal agreement as seen in (22) with verbs with the ‘recent past 2’ marker.⁸

- (22) a. bíkòn mǎdzí **bíkòn** màṅgákùs mǎkùs **bíkòn** màkǎjì
 ‘plantains’ ‘I ate the plantains that I ‘I bought the plantains that I
 bought’ wanted’

⁸The presence of the augment is indicated by boldface type on the syllable on which it occurs.

b.	mím̀bàŋ 'palm nuts'	mădzí mím̀bàŋ mǎkùs 'I ate the palm nuts that I bought'	mǎkùs mím̀bàŋ mǎkójì 'I bought the palm nuts that I wanted'
c.	ódzòì 'banana'	mădzí ódzòì mǎkókùs 'I ate the banana that I bought'	mǎkùs ódzòì mǎkójì 'I bought the banana that I wanted'
d.	ónòn 'bird'	mădzí ónòn mǎkókùs 'I ate the bird that I bought'	mǎkùs ónòn mǎkójì 'I bought the bird that I wanted'
e.	ówùndò 'peanut'	mădzí ówùndò mǎkókùs 'I ate the peanuts that I bought'	mǎkùs ówùndò mǎkójì 'I bought the peanuts that I wanted'
f.	bílók 'grass'	ědzí bílók mǎkùs '(The cow) ate the grass that I bought'	mǎkùs bílók mǎkójì 'I bought the grass that I wanted'
g.	òdzói 'duiker'	mădzí ódzói mǎkùs 'I ate the duiker that I bought'	mǎkùs ódzói mǎkójì 'I bought the duiker that I wanted'
h.	òsán 'squirrel'	mădzí ósán mǎkókùs 'I ate the squirrel that I bought'	mǎkùs ósán mǎkójì 'I bought the squirrel that I wanted'
i.	bítétám 'okra (pl.)'	mădzí bítétám mǎkùs 'I ate the okra that I bought'	mǎkùs bítétám mǎkójì 'I bought the okra that I wanted'
j.	ésíngì 'cat'	mădzí ésíngì mǎkùs 'I ate the cat that I bought'	mǎkùs ésíngì mǎkójì 'I bought the cat that I wanted'
k.	òfùmbí 'orange'	mădzí ófùmbí mǎkùs 'I ate the orange that I bought'	mǎkùs ófùmbí mǎkójì 'I bought the orange that I wanted'

In these examples, it can be seen that all nouns surface with the initial high tone from the augment. This is different from the pattern that occurs with nouns without the augment, which exhibit tonal agreement after this verb tense, as was shown in (16). However, this pattern is also distinct from the pattern of initial high tone assignment, as is demonstrated by the examples in (23) with verbs with the 'recent past 1' marker.

- (23)
- | | | | |
|----|------------------------|--|--|
| a. | bíkòn
'plantains' | màkó ¹ dzí bíkòn mǎkókùs
'I ate the plantains that I bought' | mǎkókùs ékòn mǎkójì
'I bought the plantain that I wanted' |
| b. | mím̀bàŋ
'palm nuts' | màkó ¹ dzí mím̀bàŋ mǎkókùs
'I ate the palm nuts that I bought' | mǎkókùs mím̀bàŋ mǎkójì
'I bought the palm nuts that I wanted' |

c.	ódzòì 'banana'	màkó ⁺ dží ódžòì màkókùs 'I ate the banana that I bought'	màkókùs ódžòì màkójì 'I bought the banana that I wanted'
d.	ónòn 'bird'	màkó ⁺ dží ónòn màkókùs 'I ate the bird that I bought'	màkókùs ónòn màkójì 'I bought the bird that I wanted'
e.	ówùndò 'peanut'	màkó ⁺ dží ówùndò màkókùs 'I ate the peanuts that I bought'	màkókùs ówùndò màkójì 'I bought the peanuts that I wanted'
f.	bílók 'grass'	jàkó ⁺ dží bílók màkókùs '(The cow) ate the grass that I bought'	màkókùs bílók màkójì 'I bought the grass that I wanted'
g.	òdžói 'duiker'	màkó ⁺ dží ódžói màkókùs 'I ate the duiker that I bought'	màkókùs ódžói màkójì 'I bought the duiker that I wanted'
h.	òsán 'squirrel'	màkó ⁺ dží ósán màkókùs 'I ate the squirrel that I bought'	màkókùs ósán màkójì 'I bought the squirrel that I wanted'
i.	bítétám 'okra (pl.)'	màkó ⁺ dží bítétám màkókùs 'I ate the okra that I bought'	màkókùs bítétám màkójì 'I bought the okra that I wanted'
j.	ésíngì 'cat'	màkó ⁺ dží ésíngì màkókùs 'I ate the cat that I bought'	màkókùs ésíngì màkójì 'I bought the cat I wanted'
k.	òfùmbí 'orange'	màkó ⁺ dží ófùmbí màkókùs 'I ate the orange that I bought'	màkókùs ófùmbí màkójì 'I bought the orange that I wanted'

In (23), the nouns have an initial high tone from the augment, just as all direct object nouns became initially high-toned after verbs with the 'recent past 1' marker in (18). However, the crucial difference between the process of initial high tone assignment seen in (18) and the presence of the augment in (23) is that when the augment occurs on the initial syllable of the noun, the subsequent tones of the word do not change. Therefore, the nouns in (23f-23i) differ in tone from the nouns in (18f-18i). Specifically, even if the initial low tone that is replaced by the high tone of the augment is the only L in the word, it is not realized later in the word as was seen with the process of initial high tone assignment. Instead, the addition of the augment only affects the initial tone, and the subsequent tones in the word remain unchanged. This demonstrates that the data seen in (22) and (23) reflect a different process from the initial high tone assignment discussed in Section 2.2.2.

The differences between the tone patterns of augmented nouns versus nouns that have become initially high-toned due to the process of initial high tone assignment could be explained in a variety of ways. One possibility is that these patterns reflect differences in the point in the derivation at which these high tones come about on the noun. The augment, as a distinct morpheme added to the word just as a noun class prefix would be, may reflect a lexical level of tone assignment. In contrast, the grammatical high tone triggered as a result of the preceding verb

morphology may reflect a post-lexical process. Therefore, it may be that the weight placed on preserving lexical low tones later in the word only applies at the post-lexical level. This difference in tone structure of these words may also be partially motivated by factors relating to recoverability. The tonal differences between the examples in (18f-18i) and (23f-23i) help to distinguish between the non-augmented forms and the augmented forms. If augmented nouns were subject to the same patterns of tonal change in the subsequent tones of the word as nouns that undergo initial high tone assignment, this distinction would be neutralized and the presence of the augment obscured.

To answer the question of why these augmented nouns are not subject to the same tonal processes as non-augmented nouns, it is useful to appeal to the concept of prosodic phrase structure, in line with Gimba (1998). The direct object nouns in (14-19) that undergo the process of tonal agreement or initial high tone assignment form a Phonological Phrase with the preceding verb. This is shown in (24), where brackets indicate prosodic domain boundaries.

(24) [P-P[wǎkùs] [wbítétám]]

In this example, [P-P] indicates a Phonological Phrase (P-phrase) and [w] indicates a Phonological Word. The verb and the direct object noun form a single P-phrase, and the process of tonal agreement then applies within the P-phrase.

However, when the augment and post-nominal modifiers are added, as in the examples in (22) and (23), this changes the phonological phrasing. The addition of these elements causes the augmented noun to form a P-phrase with the post-nominal modifier instead of with the verb as seen in (25).

(25) [w ǎkùs] [P-P[wbítétám] [wmàkójì]]

In this example, the verb is not part of the P-phrase occupied by the direct object noun. Because of this, the process of tonal agreement does not apply and the noun surfaces with the initial high tone from the augment. Therefore, it is posited that, for Bulu, the processes of tonal agreement and initial high tone assignment are conditioned by the phonological phrasing. Specifically, these tonal processes are restricted to occurring within a P-phrase. If a P-phrase boundary intervenes between the verb and object noun, these processes do not apply.

3 Analysis

The theories of autosegmental phonology and Optimality Theory discussed in Sections 1.2.1 and 1.2.2 can be used in conjunction with one another to represent and analyze the Bulu data seen in Section 2. By positing a series of constraints and constraint rankings for the grammar of Bulu, OT can be used to describe the patterns of both tonal agreement and initial high tone assignment. These two patterns are discussed separately in Sections 3.1 and 3.2. Data from an experimental nonce word task is included to examine the productivity of these two processes and to support the analyses given. Furthermore, autosegmental representations are used to demonstrate the structure of these Bulu words and to show how these two processes of tonal agreement and initial high tone assignment can be viewed in a unified manner.

3.1 Analysis of Tonal Agreement

The tonal alternations seen in (14-16) must be motivated by some phonotactic of Bulu. Specifically, there must be a dispreference for adjacent verbs and nouns with a tonal mismatch between the final verb tone and the initial object tone. The grammar must then repair this dispreferred sequence by changing the initial tone of the object noun to match the final tone of the verb stem. Within an autosegmental framework, this pattern can be captured as a rightward spreading of the verb tone onto the object noun and a subsequent delinking of the initial object tone. These representations are given in (26) and (27).

- (26) a. $\begin{array}{ccccc} L & L & & H & L \\ | & | & & | & | \\ \text{makus} & & & \text{bi} & \text{k\`on} \end{array}$
- b. màkùs bík\`on
- (27) a. $\begin{array}{ccccc} L & L & & H & L \\ | & | & \diagdown & \# & | \\ \text{makus} & & & \text{bi} & \text{k\`on} \end{array}$
- b. màkùs bík\`on

The example in (26) shows the initial lexical tones of the verb [màkùs] ‘I buy’ and the noun [bík\`on] ‘plantains’. Because there is a tonal mismatch between the final verb stem tone and the initial object noun tone, the change represented by (27) occurs. In (27a), the low tone from the verb stem spreads onto the initial syllable of the object noun and the high tone that was associated to this syllable delinks. This results in the surface form seen in (27b), which reflects the pattern of tonal agreement.

In order to capture how the phonological grammar computes this process of agreement within an OT framework, the dispreference for the tonal mismatch between verb and object must outweigh the preference for the output to remain faithful to the tones of the input. More specifically, there must be a markedness constraint motivating the tonal agreement, and this markedness constraint must be ranked higher than the faithfulness constraint that preserves the input tones of the noun.

Hyman and VanBik (2004) note a dispreference of the grammar of Hakha Lai, a Tibeto-Burman language, for a mismatch of tone levels across syllable boundaries, including word boundaries. They propose a markedness constraint which they call the No Jumping Principle (NOJUMP), to explain the preference in Hakha Lai for changing tone levels within syllables rather than across syllable boundaries.

By positing a modified version of this NOJUMP constraint for Bulu, the tonal agreement process between verbs and nouns can be captured. For Bulu, this dispreference is for changing tone levels across the verb-noun word boundary, rather than across all syllable boundaries. Furthermore, as demonstrated in Section 2.4, the additional conditioning of phonological phrasing applies. Therefore, the markedness constraint referred to as NOJUMP in the current work only applies across the word boundary between verbs and direct object nouns when they occur within the same Phonological Phrase.

In order to select the correct output from the set of possible output candidates, the grammar of Bulu must contain other faithfulness and markedness constraints which interact with NO-

JUMP to yield the observed surface forms. The tableau in (28) shows a set of constraints that yields the correct output for a low-tone final verb followed by a high-tone initial noun.

(28)

Input: /màkùs bíkòn/	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. màkùs bíkòn			*!	
b. màkùs bíkòn				*
c. màkùs bíkòn				**!
d. màkùs bíkòn		*!		
e. màkús bíkòn	*!			

This set of constraints includes two markedness constraints (*CONTOUR and NOJUMP) and two faithfulness constraints (IDENT(T)_V and IDENT(T)_N). The NOJUMP constraint has already been discussed. The *CONTOUR constraint represents a dispreference (*) for contour tones. This is a constraint specifically against contour tones on monomoraic syllables, rather than the lexically specified contour tones found on multi-moraic syllables discussed in Section 1.2.1. Thus, this markedness constraint expresses the dispreference of the language for having more than one tone associated to a single mora.

The faithfulness constraints in (28) both take the form of IDENT constraints. These belong to a larger family of constraints that requires the identity of a certain feature of the input to remain unchanged in the output. The IDENT constraints used here are specifically constraints on the faithful realizations of tones (T). A violation of one of these constraints is incurred when the level of a tone changes between the input and the output. These two related constraints involve faithfulness to verb input tones (IDENT(T)_V) and faithfulness to noun input tones (IDENT(T)_N).

In (28), the constraints IDENT(T)_V, *CONTOUR, and NOJUMP are all ranked higher than IDENT(T)_N. Their ranking with respect to one another, however, cannot be determined from this example. The perfectly faithful candidate, Candidate a, incurs a fatal violation of the NOJUMP constraint. Candidate d, which repairs the tone mismatch between the verb and object using a contour tone, incurs a fatal violation of *CONTOUR. Candidate e repairs the illicit tone sequence by changing the verb tone. However, this violates the highly ranked IDENT(T)_V constraint, causing it to lose. Candidates b and c both only incur violations of the lowest ranked constraint, IDENT(T)_N, from changing a tone of the noun. However, Candidate c changes both tones of the noun, thereby incurring two violations of the faithfulness constraint. This results in the selection of Candidate b as the optimal candidate, and this output does, in fact, correspond to the surface form.

The same ranking of constraints also allows a high-tone initial noun to surface faithfully after a high-tone final verb, as seen in (29).

(29)

Input: /màdʒí bíkòn/	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. màdʒí bíkòn				
b. màdʒí bíkòn			*!	*

In this case, the candidate that changes the tones of the noun, Candidate b, incurs a violation of the NOJUMP constraint. The perfectly faithful candidate, however, incurs no violations of the given constraints, making it the winner.

Though (28) and (29) show the set of constraints operating on high-tone initial disyllabic object nouns, these constraints also result in the selection of the correct surface surface forms for the high-tone initial trisyllabic word [ówùndò], as seen in (30).

(30)

Input: /màkùs ówùndò/	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. màkùs ówùndò			*!	
b. ☞ màkùs òwùndò				*
c. màkùs òwùndò				**!
d. màkùs ǒwùndò		*!		
e. màkús ówùndò	*!			

In this tableau, the winning candidate, Candidate b, only incurs one violation of IDENT(T)_N. Candidate c, which preserves the deleted high tone from the initial syllable on the second syllable of the word, incurs two violations of the IDENT(T)_N constraint, causing it to lose. All the other candidates incur fatal violations of higher ranked constraints, also causing them to lose.

This set of constraints also results in the selection of the correct surface form for low-tone initial nouns following low-tone final verbs. In these cases, the perfectly faithful candidate incurs no violation of NOJUMP or any of the other constraints, making it the optimal output.

However, when a low-tone initial noun follows a high-tone final verb, this set of constraints results in the incorrect selection of an output candidate that does not correspond to the surface form, as shown in (31).

(31)

Input: /màdʒí òsán/	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. màdʒí òsán			*!	
b. ☛ màdʒí ósán				*
c. ☹ màdʒí ósàn				**!
d. màdʒí ósán		*!		
e. màdʒì òsán	*!			

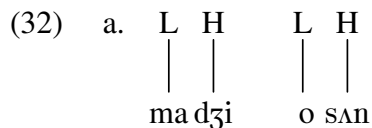
In this example, the bomb symbol indicates the candidate that is incorrectly selected, and the sad face indicates the actual surface form, which does not win with the current set of constraints. This set of constraints correctly rules out all possible output candidates except for Candidates b and c. Because Candidate b only incurs one violation of IDENT(T)_N while Candidate c incurs two, Candidate b is incorrectly selected as the optimal output.

Because the winning candidate in (31) does not correspond to the surface form, this suggests that there is some other constraint in the grammar that interacts with the given constraints to yield the correct output. Specifically, there must be a constraint that outranks IDENT(T)_N which Candidate b violates but Candidate c does not.

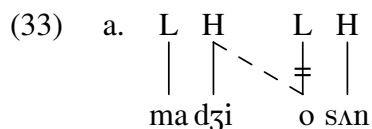
As mentioned in Section 2.2.1, the subsequent tones in an object noun appear to change only when the addition of an initial high tone would result in the deletion of the only low tone in the word. This is the situation seen in (31). Candidate c changes both tones of the object noun to preserve the low tone, incurring two violations of IDENT(T)_N. Candidate b does not

change the second tone, thus incurring only one violation of IDENT(T)_N but deleting the only low tone in the word.

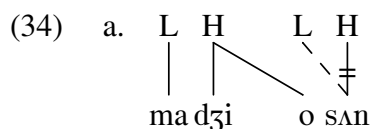
This preference for preserving low tones can be captured with an autosegmental representation. This process is shown in examples (32-34).



b. mādʒí òsʌn



b. mādʒí ósʌn



b. mādʒí ósʌn

The autosegmental diagram in (32a) shows the lexical tones of the verb [mādʒí] ‘I eat’ and the noun [òsʌn] ‘squirrel’. The representation in (33a), shows the tone of the verb stem spreading onto the initial syllable of the noun because of the tonal mismatch. The lexical low tone of the noun is delinked, yielding the form seen in (33b). However, in this form, the only low tone of the noun has been deleted. Therefore, this delinked low tone docks to the second syllable of the noun, and the high tone originally associated to that syllable delinks, as shown in (34a). This results in the correct surface form given in (34b).


To capture this pattern within an OT framework, there must be a constraint against the deletion of the only low tone within a word. If this constraint is ranked above the constraint IDENT(T)_N, candidates which do not preserve the low tone would incur a fatal violation of this constraint. The candidate that changes both tones of the noun in order to preserve the low tone would then be selected as the optimal output.

In analyzing the tone system of the Bantu language Phuthi, Donnelly (2007) discusses a constraint called CONTRAST. A candidate incurs a violation of this constraint when there is no expression of a low or high tone within a low or high tone domain. Within the framework used by Donnelly (2007), a tonal domain is a specific portion of a word or phrase over which a given tone may be expressed, and these domains are specified in the input. Therefore, when the contrast between a domain containing a certain input tone and a domain not containing that input tone is not preserved in the output due to the deletion of all surface expressions of the tone, the output candidate violates the CONTRAST constraint.

This work will adopt a slightly modified version of this constraint: CONTRAST(L). A candidate incurs a violation of CONTRAST(L) when there is no expression of a low tone in the output within a domain that contained a low tone in the input. The domain, in this case, will be defined as the Phonological Word. This constraint must be ranked above the constraint IDENT(T)_N to achieve the desired result.

When the two candidates of interest from (31) are reevaluated with the addition of the CONTRAST(L) constraint, the correct surface form is selected as the winning candidate, as seen in (35).

(35)

Input: /màdʒí ósán/	CONTRAST(L)	IDENT(T) _N
a. màdʒí ósán	*!	*
b.  màdʒí ósàn		**


This tableau only shows the relevant candidates and the constraints needed to differentiate the two. Crucially, CONTRAST(L) is ranked above IDENT(T)_N to yield the correct surface form. However, the ranking of CONTRAST(L) with respect to the remainder of the constraints utilized thus far cannot be determined from these data.

CONTRAST(L) implies the existence of CONTRAST(H). However, it is useful to note that the constraint CONTRAST(H) is either not included in the phonological grammar of Bulu or is ranked below all the constraints discussed thus far. Were this constraint to be equally ranked with CONTRAST(L), there would be an equal preference to preserve the only high tone within a word. This pattern, however, is not reflected in the Bulu data. In fact, in cases such as the one illustrated in (28), the candidate which deletes the only high tone of the noun is the optimal output and the actual surface form.

The presence of CONTRAST(L) in the grammar of Bulu also suggests some fundamental things about the status of low tones in the language. Level tone languages with a surface contrast between H and L can often be analyzed as actually displaying a contrast between H and ∅ underlying (Hyman 2000). In such cases, syllables that are not specified as high-toned are filled with a ‘default’ low tone. The weight that the grammar of Bulu places on preserving low tones would suggest, however, that Bulu maintains an underlying distinction between H and L. The presence of the CONTRAST(L) constraint also supports Donnelly’s (2007) suggestion that low tone domains can play an important role in the phonology of a language, rather than high tone domains alone.

The set of constraints used thus far can also be effectively used to account for trisyllabic nouns of the tone patterns L-H-L and L-L-H after high-toned verb stems. This can be seen in (36) and (37), respectively.

(36)

Input: /màdʒí èsíngì/	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. màdʒí èsíngì			*!	
b.  màdʒí ésíngì				*
c. màdʒí ésíngì				**!
d. màdʒí èsíngì		*!		
e. màdʒì èsíngì	*!			

(37)

Input: /màdʒí òfùmbí/	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. màdʒí òfùmbí			*!	
b. màdʒí ófùmbí				*
c. màdʒí ófùmbì				**!
d. màdʒí òfùmbí		*!		
e. màdʒì òfùmbí	*!			

In these tableaux, the perfectly faithful candidates (a) incur fatal violations of NOJUMP. The candidates which repair the tonal mismatch by using a contour tone (d) or by changing the tone of the verb (e) also incur fatal violations of highly ranked constraints. The winning candidates (b), only change the initial noun tone in order to repair the tonal mismatch, incurring one violation of IDENT(T)_N. The candidates which change additional tones in the noun to preserve the initial low tone later in the word (c) incur two violations of IDENT(T)_N. Because the initial low tone is not the only low tone in these words, changing it to a high tone is not a violation of CONTRAST(L). Therefore, Candidate c in each of these tableaux loses because it has more violations of IDENT(T)_N than Candidate b.

However, when the given constraint set is applied to a trisyllabic noun with the tone pattern L-H-H, as seen in (38), the surface form is not correctly selected as the optimal output.

(38)

Input: /màdʒí bìtétám/	IDENT(T) _V	*CONTOUR	NOJUMP	CONTRAST(L)	IDENT(T) _N
a. màdʒí bìtétám			*!		
b. màdʒí bìtétám				*!	*
c. màdʒí bìtétám					**
d. màdʒí bìtétám					***!
e. màdʒí bìtétám		*!			
f. màdʒì bìtétám	*!				

The set of constraints correctly rules out all possible output candidates except for Candidates c and d. Candidate c avoids a violation of CONTRAST(L) by preserving the initial low tone on the second syllable of the noun. This results in two violations of IDENT(T)_N. Candidate d transfers the initial low tone to both the second and third syllables of the noun, resulting in a violation of IDENT(T)_N for each syllable for a total of three violations. Because Candidate c has fewer violation of the IDENT constraint than Candidate d, it is incorrectly selected as the winner.

The noun [bìtétám] ‘okra (pl.)’ is the only noun in the data set with the tone pattern L-H-H. This raises a question of whether the pattern of tonal changes seen in (38) is simply a memorized exception of the language or if this particular pattern and the constraints responsible for it are a productive part of the grammar of Bulu. If this is a memorized exception, then proposing a new constraint to explain the data is not necessary since speakers would be treating

this word as a lexical exception rather than a word conforming to the normal constraints of the grammar. However, if this pattern of tonal changes is productive, the grammar must be able to explain the observed surface form.

To test the productivity of this pattern in Bulu, the consultant was presented with an experimental task involving various nonce words with multiple different tonal melodies⁹. The speaker was presented with illustrations of fictional creatures and was given a nonce word as a name for that type of animal. The speaker was asked to insert these nonce words into various carrier sentences to test which patterns of tonal change would be applied to these words. Some carrier sentences placed the word in subject position to ensure that the speaker had learned the correct tonal melody for the word. Some sentences required the speaker to form the plural of the noun to avoid potential proper name effects by ensuring that the words were being treated as words for a type of creature rather than a name for a particular creature¹⁰. Some carrier sentences placed the noun as the head of a relative clause to ensure that correct tonal changes due to the augment were being applied. Finally, some carrier sentences inserted the noun into the position after the verb to note the effects of tonal agreement or initial high tone assignment, depending on the tense of the preceding verb.

The data in (39) show a small portion of the results from this task to illustrate tonal agreement with nouns of the tonal melody L-H-H.

- | | | | | |
|------|----|--------|----------------|------------------|
| (39) | a. | òkáné | bàdží ókànè | àngákùs òkáné |
| | | | ‘It ate an X’ | ‘He bought an X’ |
| | b. | èfámhá | àngádží èfámhá | màngákùs èfámhá |
| | | | ‘He ate an X’ | ‘I bought an X’ |

These examples show that the nonce words of the tonal melody L-H-H change to H-L-L after the high-toned verb stem [dží] ‘eat’ just as the Bulu word [bítétám] does. These data suggest that this is, then, a productive pattern in Bulu. A further example in (40) confirms that nonce words also pattern in the same way as the Bulu word in environments triggering initial high tone assignment.

- | | | | |
|------|--------|------------------------------|--------------------|
| (40) | èfámhá | jákó ⁺ dží èfámhá | màkókùs bífámhá |
| | | ‘(The dog) ate an X’ | ‘I bought X (pl.)’ |

Because these nonce words behave in a patterned way, this suggests that the processes causing the tonal patterns are productive and not memorized exceptions of the language. As productive processes of the phonological grammar, these patterns must be accounted for via constraints in an OT framework.

In many Bantu languages, high tones on adjacent syllables are often analyzed as being realizations of a single high tone feature (Donnelly 2007, *inter alia*). This analysis is frequently adopted to explain the phonological contrasts between two surface high tones that seem to behave as a single unit versus two surface high tones that behave as separate entities, and this approach can be helpful in explaining patterns such as downstep.

In line with this type of analysis, it could be posited that the final two high tones in the word [bítétám], and all other nouns of the melody L-H-H, are actually surface realizations of a single

⁹I owe many thanks to my advisor, Rebecca Morley, for suggesting that I investigate productivity by means of a nonce word experiment.

¹⁰I must also thank Jefferson Barlew for suggesting this modification to the experiment design.

high tone. When the initial low tone becomes high after a high-toned verb stem, the low tone is then preserved on both of the following two syllables. This pattern could be motivated by a constraint stipulating that these two syllables must remain associated to a single tone in the output if they were associated to a single tone in the input. A constraint of the common family of DEP constraints against epenthesis could be used to achieve this result. The faithfulness constraint DEP(T), constrains an output form from epenthesizing an additional tone that was not in the input form. This constraint must dominate IDENT(T)_N to yield the correct result. The example in (41) shows the effect of this constraint in selecting between the two relevant candidates from (38).

(41)

Input: /màdʒí bìtè ₁ tá ₁ m/	DEP(T)	IDENT(T) _N
a. màdʒí bìtè ₁ tá ₂ m	*!	**
b. màdʒí bìtè ₁ tà ₁ m		***

With the addition of the new DEP(T) constraint, the actual surface form (Candidate b) is correctly selected as the optimal output. The subscript numbers in this tableaux are used as indices for the relevant tones in the noun. In the input form, the final two tones are both indexed with the same number, indicating that they both share a single high tone feature. In Candidate a, the second syllable is low and the third syllable is high. The numbers indicate that these two syllables no longer share a single tonal feature but have been split with an extra tone being added. Therefore, this candidate incurs a fatal violation of the constraint DEP(T). In Candidate b, however, both syllables remain a realization of a single tone, now a low tone. This candidate avoids a violation of DEP(T), making it the winning candidate.

From the preceding data, therefore, the constraint ranking in (42) is posited.

(42) IDENT(T)_V, *CONTOUR » NOJUMP, CONTRAST(L), DEP(T) » IDENT(T)_N

The following section will analyze how these constraints can also be used to help arrive at the optimal output for instances of initial high tone assignment.

3.2 Analysis of Initial High Tone Assignment

The process of initial high tone assignment can be represented simply within an autosegmental framework, as demonstrated in (43) and (44).

(43) a. H L L H H L
 \ | | | |
 mejkus bi kòn

b. mèjkùs bíkòn

(44) a. H L L H H L
 \ | | \ |
 mejkus bi kòn

b. mèjkùs bíkòn

Both (43b) and (44b) shown the same phonetic realization of the tones. The difference between the associations of the lexical tones seen in (43a) and the changed associations seen in (44a) is that the floating high tone accompanying the verb has spread onto the initial syllable of the noun. This results in the noun surfacing with the initial high tone rather than the initial low tone that would have resulted from a process of tonal agreement. However, this example reflects the same pattern of rightward spreading seen with tonal agreement. The only difference is that it is the floating high tone that is spread instead of the final verb tone.

However, when the constraints used in the previous analysis to model tonal agreement within an OT framework are applied to a form that shows a pattern of initial high tone assignment, one problem becomes immediately apparent, as seen in (45).

(45)

Input: /mêjkùs' bíkòn/	NOJUMP	IDENT(T) _N
a. ☹ mējkùs bíkòn	*!	
b. ☹ mējkùs bìkòn		*

When initial high tone assignment occurs after a low-toned verb stem, the actual surface form incurs a violation of NOJUMP, just as Candidate a does in the above example. This causes the candidate displaying tonal agreement (Candidate b, in this case) to incorrectly win.

In order to arrive at the correct surface forms, the grammar must contain an additional constraint that causes candidates with initial high tones to win despite violations of NOJUMP. Because the verb tenses that condition initial high tone assignment are posited to have a final floating high tone, this constraint can take the form of a faithfulness constraint necessitating the faithful realization of this floating tone in the output. Specifically, this pattern can be modeled with a constraint from the family of MAX constraints that prohibit the deletion of an element of the input in the output form. If the constraint MAX(T)_V, which constrains the deletion of verb tones, is posited, any output candidate that does not contain a realization of the floating high verb tone from the input will incur a violation of this constraint. If this constraint dominates NOJUMP, the desired effect of selecting the output candidates that demonstrate initial high tone assignment rather than tonal agreement can be achieved. This is demonstrated in (46).

(46)


Input: /mêjkùs' ₁ bí ₂ kòn/	MAX(T) _V	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. mējkùs bí ₂ kòn	*!			*	
b. ☹ mējkùs bí ₁ kòn				*	
c. mējkùs bì ₂ kòn	*!				*
d. mējkùs bì ₁ kòn		*!			
e. mējkũ ₁ s bí ₂ kòn			*!		

In this example, the two candidates (a and c) that delete the floating high tone of the verb incur fatal violations of MAX(T)_V. Candidate e preserves the tone by allowing it to surface on the final syllable of the verb, but this results in a violation of *CONTOUR. Candidate d also preserves the floating tone, but changes it to a low to avoid a violation of NOJUMP. This,

however, violates IDENT(T)_V. Therefore, Candidate b, which preserves the floating high tone by allowing it to surface on the noun, is correctly selected as the optimal output.

This set of constraints also results in the desired outcome for trisyllabic high-tone initial nouns, as seen in (47).

(47)

Input: /mêjkùs' ₁ ó ₂ wòndò/	MAX(T) _V	IDENT(T) _V	*CONTOUR	NOJUMP	IDENT(T) _N
a. mējkùs ó ₂ wòndò	*!			*	
b.  mējkùs ó ₁ wòndò				*	
c. mējkùs ò ₂ wòndò	*!				*
d. mējkùs ò ₁ wòndò		*!			
e. mējkũ ₁ s ó ₂ wòndò			*!		

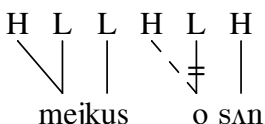
Just as in (46), Candidate b, which allows the initial high tone of the verb to surface faithfully on the initial syllable of the noun, is selected as the optimal output candidate.

Representing initial high tone assignment on low-tone initial nouns within an autosegmental framework requires an additional step from the patterns seen in (43) and (44). This is demonstrated in (48-50) below.

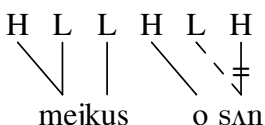
(48)

- a. 
- b. mējkùs òsán

(49)

- a. 
- b. mējkùs ósán


(50)

- a. 
- b. mējkùs ósàn

In (49a), the floating high tone from the verb is docked to the initial noun syllable, causing the low tone associated to that syllable to delink. However, this low tone then spreads to the second syllable of the noun, causing the high tone associated to that syllable to delink, as represented by the structure in (50a).

This analysis is supported by the grammar of tonal alternations developed in the previous section, as demonstrated by the tableau in (51).


(51)

Input: /mêjkùs' ₁ ò ₂ sán/	<i>MAX(T)_V</i>	<i>IDENT(T)_V</i>	<i>*CONTOUR</i>	<i>NoJUMP</i>	<i>CONTRAST(L)</i>
a. mêjkùs ò ₂ sán	*!				
b. mêjkùs ó ₁ sán				*	*!
c.  mêjkùs ó ₁ sà ₂ n				*	
d. mêjkùs ò ₁ sán		*!			
e. mêjkũ ₁ s ò ₂ sán			*!	*	


Candidates b and c both allow the floating high tone from the verb to be realized faithfully on the noun. However, Candidate b incurs a violation of CONTRAST(L), because the only low tone in the noun is deleted. Candidate c, on the other hand, preserves this low tone on the second syllable of the noun, avoiding a fatal violation of CONTRAST(L). It is therefore chosen as the winning candidate.

The correct result for trisyllabic nouns of the tonal melodies L-H-L, L-L-H, and L-H-H, also falls out from the established set of constraints and rankings as demonstrated by (52), (53), and (54), where the relevant constraints are shown.

(52)

Input: /mêjkùs' ₁ è ₂ síngì/	<i>MAX(T)_V</i>	<i>IDENT(T)_V</i>	<i>*CONTOUR</i>	<i>NoJUMP</i>	<i>IDENT(T)_N</i>
a. mêjkùs è ₂ síngì	*!				
b.  mêjkùs é ₁ síngì				*	
c. mêjkùs é ₂ síngì	*!			*	*
d. mêjkùs è ₁ síngì		*!			
e. mêjkũ ₁ s è ₂ síngì			*!	*	

(53)

Input: /mêjkùs' ₁ ò ₂ fùmbí/	<i>MAX(T)_V</i>	<i>IDENT(T)_V</i>	<i>*CONTOUR</i>	<i>NoJUMP</i>	<i>IDENT(T)_N</i>
a. mêjkùs ò ₂ fùmbí	*!				
b.  mêjkùs ó ₁ fùmbí				*	
c. mêjkùs ó ₂ fùmbí	*!			*	*
d. mêjkùs ò ₁ fùmbí		*!			
e. mêjkũ ₁ s ò ₂ fùmbí			*!	*	

(54)

Input: /mêjkùs' ₁ bì ₂ tétám/		<i>MAX(T)_V</i>	<i>*CONTOUR</i>	<i>NOJUMP</i>	<i>CONTRAST(L)</i>	<i>DEP(T)</i>	<i>IDENT(T)_N</i>
a.	mêjkùs bì ₂ tétám	*!					
b.	mêjkùs bí ₁ tétám			*	*!		
c.	mêjkùs bí ₁ tè ₂ tà ₂ m			*			**
d.	mêjkùs bí ₁ tè ₂ tá ₃ m			*		*!	**
e.	mêjkũ ₁ s bì ₂ tétám		*!	*			

In both (52) and (53), Candidate b, which allows the floating verb tone to surface faithfully on the noun, wins. In (54), Candidate c allows the floating high tone from the verb to surface on the noun while simultaneously avoiding fatal violations of CONTRAST(L) and DEP(T). It is therefore selected as the optimal output candidate.

The overall ranking of the constraints posited for the grammar of Bulu is summarized in (55).

(55) $MAX(T)_V, IDENT(T)_V, *CONTOUR \gg NOJUMP, CONTRAST(L), DEP(T) \gg IDENT(T)_N$

With this set of constraints and the given ranking, both patterns of tonal agreement and initial high tone assignment can be accurately modeled, thus providing a unified analysis of the two phenomena.

4 Conclusion

The data from original fieldwork presented in this paper provide evidence for two tonal processes affecting adjacent verbs and direct object nouns in Bulu. Furthermore, the details of these processes are different than the tonal patterns noted previously for Bulu (Yukawa 1992). Tonal agreement causes the first syllable of the object noun to surface with the same tone as the final syllable of the verb stem. Initial high tone assignment results in the first syllable of the object noun becoming high-toned regardless of the tone of the final syllable of the verb stem. Positing a floating high tone accompanying certain TAM morphemes can account for the morphological conditioning of these two processes. Additionally, prosodic conditioning accounts for the variability of these processes based on whether the verb and noun occur within the same Phonological Phrase.

Autosegmental representations capture a unified pattern common to both tonal processes by representing both as instances of tonal spreading from the verb to the noun. In cases of tonal agreement, the final verb stem tone spreads one syllable rightward onto the noun. In cases of initial high tone assignment, the floating high tone after the verb is spread rightward onto the first syllable of the noun.

Similarly, a unified account of these two processes can be captured within an OT framework. By positing a markedness constraint that constrains a change in tone level across the word boundary between verb and noun (NOJUMP), the basic pattern of tonal agreement can be achieved. The addition of the faithfulness constraint CONTRAST(L) crucially prevents the

only low tone in a word from being deleted. Furthermore, by positing a constraint that preserves verb input tones ($\text{MAX}(\text{T})_V$) and that dominates NOJUMP, the pattern of initial high tone assignment can be accounted for as well.

The prominent role of low tones in these processes in Bulu suggests an underlying tonal contrast different than the H vs. \emptyset often posited for Bantu languages. It raises questions as to the function of low tones in the tone system of Bulu as a whole. Further topics to be investigated include the status of floating low tones in causing downstep more generally in Bulu, in addition to the limited cases seen in this work. Likewise, it remains to be seen whether the constraint CONTRAST(L) can explain other phonological processes and tonal patterns in the language. The current work, however, lays a foundation for future investigations by providing evidence for the important status of low tones and an additional source of fieldwork data from Bulu.

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